07-19-00 A

UTILITY PATENT APPLICATION TRANSMITTAL

(New Nonprovisional Applications Under 37 CFR § 1.53(b))

Attorney Docket No. **CY-0015**

TO THE ASSISTANT COMMISSIONER FOR PATENTS:

Transmitted herewith is the patent application of ( ) application identifier or (X) first named inventor, **Walter G. Branco**, entitled **Method for Cleaning Plasma Etch Chamber Structures**, for a(n):

(X) Original Patent Application.

( ) Continuing Application (prior application not abandoned):
( ) Continuation ( ) Divisional ( ) Continuation-in-part (CIP)
of prior application No: ______________ Filed on: ______________.
( ) A statement claiming priority under 35 USC § 120 has been added to the specification.

Enclosed are:
(X) Specification; 15 Total Pages. (X) Drawing(s); 3 Total Sheets.
(X) Oath or Declaration:
(X) A Copy of a Newly Executed Combined Declaration and Power of Attorney:
(X) Signed. ( ) Unsigned. ( ) Partially Signed.
( ) A Copy from a Prior Application for Continuation/Divisional (37 CFR § 1.63(d)).
( ) Incorporation by Reference. The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied, is considered as being part of the disclosure of the accompanying application and is hereby incorporated herein by reference.
( ) Signed Statement Deleting Inventor(s) Named in the Prior Application. (37 CFR § 163(d)(2)).
( ) Power of Attorney. (X) Return Receipt Postcard.
( ) Associate Power of Attorney. (X) A Check in the amount of $ 690.00 for the Filing Fee.
( ) Preliminary Amendment. ( ) Information Disclosure Statement and Form PTO-1449.
( ) A Duplicate Copy of this Form for Processing Fee Against Deposit Account.
( ) A Certified Copy of Priority Documents (if foreign priority is claimed).
( ) Statement(s) of Status as a Small Entity.
( ) Statement(s) of Status as a Small Entity Filed in Prior Application, Status Still Proper and Desired.
( ) Other: ______________________________.

CLAIMS AS FILED				
FOR	NO. FILED	NO. EXTRA	RATE	FEE
Total Claims	20	0	$18.00	$ 0.00
Independent Claims	3	0	$78.00	$ 0.00
Multiple Dependent Claims (if applicable)				$0.00
Assignment Recording Fee				$0.00
Basic Filing Fee				$690.00
			Total Filing Fee	$ 690.00

Pursuant to 37 CFR § 1.25, at any time during the pendency of this application, please charge any fees required or credit any overpayment to Deposit Account 50-0742.

Respectfully submitted,

By: [signature]
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Date: July 16, 2000

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I hereby certify that this is being deposited with the U.S. Postal Service "Express Mail Post Office to Addressee" service under 37 CFR § 1.10 on the date indicated below and is addressed to:

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Typed Name: Bradley Sako

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Date of Deposit: July 17, 2000

METHOD FOR CLEANING PLASMA ETCH CHAMBER STRUCTURES

TECHNICAL FIELD

The present invention relates generally to reactive plasma systems, and more particularly to the cleaning of plasma etch reactor parts.

BACKGROUND OF THE INVENTION

Most integrated circuit (IC) manufacturing processes typically include a number of manufacturing steps that can sequentially form, shape or otherwise modify various layers. One way of forming a layer can be to deposit and then etch the layer. Usually, etching can include forming an etch mask over an underlying layer. An etch mask may have a particular pattern that can mask certain portions of an underlying layer while exposing other portions. Etching can then remove portions of an underlying layer exposed by an etch mask. In this way, an etch mask pattern may be transferred to an underlying layer.

Etching may include "wet" chemical etching and "dry" plasma etching. In many cases, plasma etching can provide greater controllability and greater directional control (e.g., anisotropy) if desired.

An important issue in conventional plasma etching processes can be the redistribution of etched material. This issue will be explained with reference to FIG. 4. FIG. 4 is a side cross sectional view of various chamber parts **400** in a plasma reactor chamber that may hold a wafer **402**.

In an etch process, active species of a plasma can etch materials on a wafer **402** surface and redistributed such materials onto chamber parts **400**. If redistributed material is allowed to accumulate, such accumulated material can detach from chamber parts **400** and then land on a

wafer, possibly forming a defect. Consequently, periodic maintenance of plasma etching equipment often includes cleaning chamber parts **400** to remove material redistributed by a reactive plasma.

As noted above, conventional etching in an integrated circuit manufacturing process can include an etch mask. Etch masks are often formed from photoresist. Photoresist typically includes a polymer-based material with an activating agent. When exposed to particular electromagnetic wavelengths (e.g., visible light, X-rays, etc.) an activating agent may form crosslinks between polymers. A solvent can then be applied to a photoresist. Those portions of photoresist having crosslinks are less soluble than those portions of photoresist not having crosslinks. Thus, portions of photoresist exposed by a photomask can be removed. In this way, photolithographic techniques may then be used to "develop" and then form a pattern in photoresist with a photomask, or the like.

The transfer of a photoresist pattern to an underlying layer by etching typically relies on a high degree of selectivity between an etch mask layer and an underlying layer. However, while a plasma etch may have a such high degree of selectivity, active species within a plasma may still etch portions of an etch mask and redistribute etch mask material onto chamber parts.

Thus, periodic maintenance procedures are typically performed on etch systems to remove photoresist polymers that have been redistributed on etch chamber equipment.

A conventional plasma chamber part cleaning process will now be described with reference to **FIG. 5**. A conventional chamber part cleaning process **500** may include an initial wet chemical cleaning (step **502**). For example, chamber equipment may be submerged in a mixture of hydrogen peroxide (H_2O_2) and ammonium hydroxide (NH_2OH). More particularly, chamber equipment may be submerged in a 30% solution of H_2O_2 in a 1:1 ratio with NH_2OH

for about 20 minutes.

Following a step **502**, chamber parts may be rinsed in de-ionized (DI) water (step **504**). Pressurized nitrogen gas (N2) under may then be used to blow dry chamber parts after being rinsed (step **506**).

A method **500** may continue with an oven bake (step **508**) An oven bake may particularly include loading blown dry chamber parts into an oven and baking the chamber parts for 30 minutes at about 110 °C.

A drawback to a conventional method **500** can how such a cleaning method affects chamber part surfaces. For example, chamber parts can typically be formed from quartz. A wet clean of H_2O_2 and NH_2OH may etch quartz surfaces changing surface textures. Changes in chamber part surfaces may result in drift in an etch process, as a changing surface conditions may alter gas flows and or etch chemistry. Further, because cleaning may consume etch chamber parts, such parts may have to be periodically replaced.

A conventional method **500** may include other drawbacks. First, it has been observed that such a cleaning process may result in particles remaining on chamber parts. Thus, there may be an initial increase in particle defects following periodic maintenance of a plasma etching system. In addition, following a conventional cleaning process such as that shown in FIG. 5, redistributed polymer material may not adhere as well to etch chamber part surfaces. Consequently, such etch chamber parts may have to be cleaned with a certain minimum frequency to prevent redistributed material from accumulating to a point where it can contaminate wafers.

It would be desirable to arrive at some way of cleaning reactive plasma chamber parts that may address the various drawbacks of conventional cleaning processes.

SUMMARY OF THE INVENTION

A reactive plasma chamber may include chamber parts on which a material may be redistributed by a reactive plasma. The present invention may include methods of cleaning such a redistributed material from a chamber part.

According to one aspect of the invention, a method of cleaning a chamber part may include dipping a chamber part in a solvent for the redistributed material. A chamber part may then be rinsed of a solvent.

According to another aspect of the invention, a redistributed material may include photoresist polymers and a solvent may include acetone. Acetone may be rinsed with de-ionized water.

According to another aspect of the invention, a method of cleaning a chamber part may include plasma cleaning a chamber part with a reactive plasma having a high degree of selectivity between a redistributed material and a chamber part material.

According to another aspect of the invention, a redistributed material may include photoresist polymers and a reactive plasma may include oxygen as a source gas.

According to another aspect of the invention, a chamber part may be ultrasonically cleaned in an ultrasonic cleaning liquid. After an ultrasonic cleaning, a chamber part may be rinsed with a liquid having a lower evaporating temperature than an ultrasonic cleaning liquid.

According to another aspect of the invention, a chamber part may be blown dry and then baked.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a flow diagram of a first embodiment of the present invention.

FIG. 2 is a flow diagram of a second embodiment of the present invention.

FIG. 3 is a flow diagram of a third embodiment of the present invention.

FIG. 4 is a side cross sectional view showing one example of a reactive plasma chamber.

FIG. 5 is flow diagram showing a conventional etch chamber part cleaning method.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Various embodiments will now be described in conjunction with a number of diagrams. The embodiments set forth a method of cleaning plasma reactor equipment. In particular, methods for cleaning material from plasma reactor chamber parts that may have been redistributed from a wafer onto the chamber parts in a plasma etch process.

Referring now to FIG. 1, a flow diagram is set forth that shows a method of cleaning plasma reactor equipment according to a first embodiment. A first embodiment is designated by the general reference character **100** and may include a solvent dip (step **102**). A solvent dip **102** may include immersing one or more pieces of plasma reactor equipment into a solvent. A solvent may be a solvent that can dissolve a material that has been redistributed onto a chamber part. For example, the solvent may be an organic solvent, such as acetone, methanol, ethanol, propanol, isoproponal, butanol, sec-butonal, methyl ethyl ketone (MEK), tetrahydrofuran, diethyl ether, methyl t-butyl ether, dimethyl sulfoxide, or N-methyl pyrolidone, to name but a few examples.

A first embodiment **100** may further include a solvent rinse (step **104**). A solvent

rinse **104** may include immersing and/or spraying a piece of chamber part to substantially remove solvent that may remain after a step **102**.

After a solvent has been rinsed, a rinsed piece of equipment may be ultrasonically cleaned (step **106**). An ultrasonic clean **106** may include submersing a piece of plasma reactor equipment in an ultrasonic cleaning liquid that can be subjected to vibrations at an ultrasonic frequency.

A first embodiment **100** may also include an evaporative liquid rinse (step **108**). An evaporative liquid rinse **108** may include immersing and/or spraying a chamber part with a liquid that may evaporate at a lower temperature than an ultrasonic cleaning liquid.

After an evaporative liquid rinse **108**, a chamber part can be blown dry (step **110**). A step **110** may include spraying a chamber part with an inert gas that is under pressure. Such a drying step can accelerate the evaporation of a rinse liquid from step **108**.

As shown in FIG. 1, a chamber part may then be baked (step **112**). Baking **112** may include placing a chamber piece part into an oven at a temperature greater than room temperature for a predetermined period of time.

In this way, a chamber part having redistributed material thereon may be cleaned with a method that includes a dip (step **102**) in a liquid that can be a solvent for the redistributed material. Such a dip may remove redistributed material from chamber parts without etching such chamber parts.

Referring now to FIG. 2, a second embodiment is disclosed in a flow diagram. A second embodiment is designated by the general reference character **200** and may include a plasma clean (step **202**). A step **202** may include plasma cleaning chamber parts with a recipe that is highly selective between plasma a chamber part and a material that has been

redistributed on such a chamber part.

A second embodiment **200** may continue with steps like those described in conjunction with the first embodiment. To that extent, like references will be referred to by the same reference character but with the first digit being a "2" instead of a 1. To avoid undo repetition, a description of such steps will not be repeated.

A third embodiment will now be described with reference to FIG. 3. A third embodiment may include a method of cleaning redistributed etch mask material from plasma reactor chamber parts. More particularly, a third embodiment shows method of cleaning polymer-based photoresist from quartz chamber parts used in reactive plasma etching.

A third embodiment is designated by the general reference character **300** and may include an acetone dip (step **302**). Acetone dip **302** can be a photoresist polymer solvent and may dissolve redistributed photoresist polymers formed on chamber parts. A step **302** may include filling a receptacle with acetone. Quartz chamber parts may then be submerged in acetone for a period of time that may be greater than 2 hours, less than 48 hours, even more particularly from about 6-24 hours.

In this way a solvent dip may be used to remove redistributed material from plasma reactor chamber parts.

A third embodiment **300** may further include a de-ionized (DI) water rinse (step **304**). A step **304** may include placing quartz chamber parts that have been dipped in acetone under running DI water and/or a DI water bath. In one particular arrangement, quartz chamber parts may be placed under running DI water for about 10 to 60 minutes, more particularly about 15 to 30 minutes, even more particularly about 20 minutes.

A third embodiment **300** may also include an oxygen plasma clean (step **306**). An

oxygen plasma clean may include the steps of placing quartz chamber parts into a reactive plasma chamber. Quartz chamber parts may then be subjected or exposed to plasma that includes a source of oxygen such as O_2 gas, ozone, NO, N_20, NO_2 or SO_2, but preferably comprises O_2, optionally in the presence of an inert gas such as He, Ne, Ar and/or N_2. In an oxygen plasma clean, a plasma chamber may be at a pressure in the general range of 200 mTorr to 2 Torr, more particularly about 1 Torr. Reactor chamber power may be in the general range of 500-1200 Watts, more particularly about 600-1000 Watts, even more particularly about 800 Watts. Such an oxygen plasma cleaning may last from 30-60 minutes, more particularly about 45 minutes.

In one particular arrangement, oxygen plasma cleaning may include an initial oxygen plasma clean that lasts for 45 minutes. Quartz chamber parts may then be removed and inspected. If residual photoresist remains, the quartz chamber parts may be oxygen plasma cleaned and inspected once again until they appear sufficiently clean. Such subsequent oxygen plasma cleans can be for 15 minutes, as but one example.

Plasma cleaning with oxygen as a source gas (also referred to "ashing") can remove organic based materials, such a polymer-based photoresist. At the same time, an oxygen plasma etch can leave quartz surfaces essentially unaltered. In this way, unlike conventional cleaning methods that may consume quartz material in an H_2O_2 and NH_2OH dip, a third embodiment **300** may clean quartz material with a solvent and/or plasma clean that consumes essentially no quartz material.

A third embodiment **300** may continue with a DI water ultrasonic clean (step **308**). A step **308** may include submersing quartz chamber equipment in DI water that may be subject to vibrations at an ultrasonic frequency. In one particular approach, two quartz chamber

parts may be placed in an ultrasonic machine for a cycle lasting between 15 and 60 minutes, more particularly about 30 minutes.

A third embodiment **300** may also include a volatile solvent rinse (step **310**), for example using isopropyl alcohol (IPA) or an organic solvent from the above list having a boiling point below 100 °C, preferably below 90 °C. A step **310** may include rinsing quartz chamber parts with a squirt bottle containing IPA.

After an IPA rinse **310**, a chamber part can be blown dry with nitrogen gas N_2. N_2 gas may be an inert gas that is essentially non-reactive to quartz chamber parts and/or the atmosphere. An N_2 blow dry step can accelerate the evaporation of IPA.

As shown in FIG. 3, quartz chamber parts may then be baked (step **314**). A step **314** may include placing quartz chamber parts in a top shelf of an oven. Such an oven may be at a temperature in the general range of 75-~~100~~ 150 °C, in particular about 10 80-120 °C, more WB 7/13/00 particularly about 110 °C. Further, such a baking may have a duration of about 15-60 minutes, more particularly about 30 minutes.

The present invention can provide an improved cleaning process for removing redistributed photoresist from plasma reactor chamber parts. It has been found that a method according to the present invention may increase maintenance cycle times from about less than 80 RF hours in the conventional case of FIG. 5, to more than 120 RF hours. RF hours include the times at which RF power is applied to a plasma etch machine. Such increases in maintenance cycle times can reduce maintenance costs and/or add to the throughput of a manufacturing process, as machines can be available for longer periods of time.

In addition, or alternatively, the present invention can reduce wear on chamber parts for a plasma reactor system. This can decrease cost of ownership for such a plasma reactor system,

as parts may have to be replaced less frequently than in the case of conventional cleaning methods.

A cleaning method according to the present invention may advantageously clean parts having small openings. In particular, the present invention may be used to clean a gas distribution plate in a plasma reactor system. A gas distribution plate may include holes that can be difficult to clean. Other particular types of chamber parts that may be cleaned can include a viewport window and/or a shadow ring, which can surround a wafer in a reactor chamber.

It is understood that particular examples disclosed herein should not be construed as limiting to the invention. For example, a particularly advantageous application of an acetone dip for photoresist polymer residue removal has been disclosed as one particular solvent/material combination, other solvent/material combinations may be possible. Along these same lines, while a particularly advantageous application of an oxygen plasma clean for photoresist polymer residue removal has been disclosed as one particular plasma/material combination, the teachings herein may be applied to arrive at other plasma/material combinations.

Thus, while the various particular embodiments have been set forth herein, methods according to the present invention could be subject to various changes, substitutions, and alterations without departing from the spirit and scope of the invention. Accordingly, the present invention is intended to be limited only as defined by the appended claims.

IN THE CLAIMS

What is claimed is:

1. A method, comprising:

cleaning a plasma reactor chamber part, that may have a material redistributed thereon by a reactive plasma process, by placing the chamber part in a redistributed material solvent.

2. The method of claim 1, wherein:

the material includes photoresist polymers and the solvent includes acetone.

3. The method of claim 1, wherein:

the chamber part comprises quartz.

4. The method of claim 1, wherein:

the chamber part is placed in the solvent for at least 6 hours.

5. The method of claim 1, further including:

cleaning the chamber part with a plasma that includes oxygen as a source gas.

6. The method of claim 5, wherein:

the plasma is formed with a radio frequency (RF) power in the general range of 500 to 1000 W.

7. The method of claim 5, further including:

rinsing the chamber part after cleaning with the solvent but before the plasma cleaning.

8. The method of claim 1, further including:

ultrasonically cleaning the chamber part.

9. The method of claim 1, further including:

baking the chamber part at a temperature in the general range of 75-150 °C.

10. A method of cleaning a plasma reactor chamber part, comprising:

plasma cleaning a chamber part, that may have having a material redistributed on the chamber part by a reactive plasma process, with a plasma having an etch selectivity between the chamber part and the redistributed material that is greater than 1:100.

11. The method of claim 10, wherein:

the chamber part comprises quartz and the plasma includes oxygen as a source gas.

12. The method of claim 10, wherein:

the plasma is formed with a radio frequency (RF) power in the general range of 500 to 1000 W.

13. The method of claim 10, wherein:

the redistributed material includes photoresist polymers.

14. The method of claim 10, further including:

cleaning the chamber part with a solvent of the redistributed material.

15. A method of cleaning reactive plasma chamber parts, comprising the steps of:

applying an organic solvent to a surface of a chamber part; and

oxygen plasma cleaning the chamber part.

16. The method of claim 15, wherein:

the organic solvent includes acetone.

17. The method of claim 15, further including:

rinsing the chamber part with de-ionized water after applying the organic solvent.

18. The method of claim 15, further including:

ultrasonically cleaning the chamber part after the oxygen plasma cleaning.

19. The method of claim 18, further including:

rinsing the chamber part with a liquid that evaporates at a lower temperature than water after the ultrasonic cleaning.

20. The method of claim 15, further including:

baking the chamber part at a temperature greater than 80 °C for at least 15 minutes.

ABSTRACT OF THE DISCLOSURE

A method for cleaning a plasma reactor chamber part (**100**) may include dipping the chamber part in a solvent (**102**) that may dissolve a material that has been redistributed on the chamber part by a reactive plasma. A chamber part may then be rinsed (**104**), ultrasonically cleaned (**106**) in a ultrasonic cleaning liquid, and then rinsed again with a liquid that may evaporate at a lower temperature than an ultrasonic cleaning liquid (**108**). A chamber part may then be blown dry (**110**) and baked (**112**). In addition, or alternatively, a method may also include plasma cleaning a chamber part (**202**).

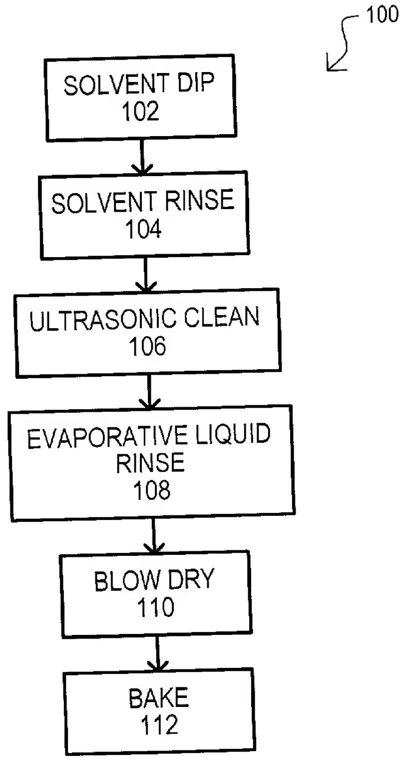
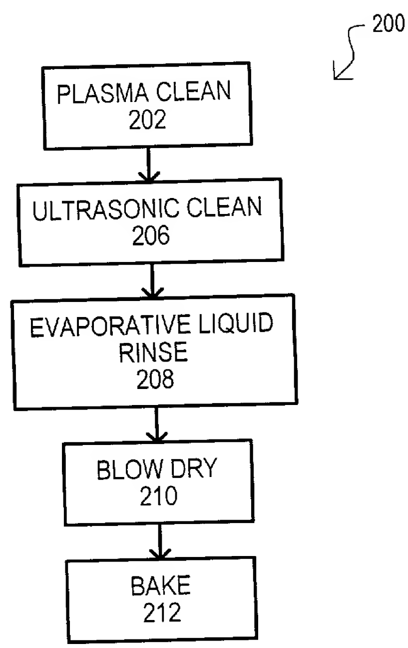

100
SOLVENT DIP 102
SOLVENT RINSE 104
ULTRASONIC CLEAN 106
EVAPORATIVE LIQUID RINSE 108
BLOW DRY 110
BAKE 112

FIG. 1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PLASMA CLEAN 202
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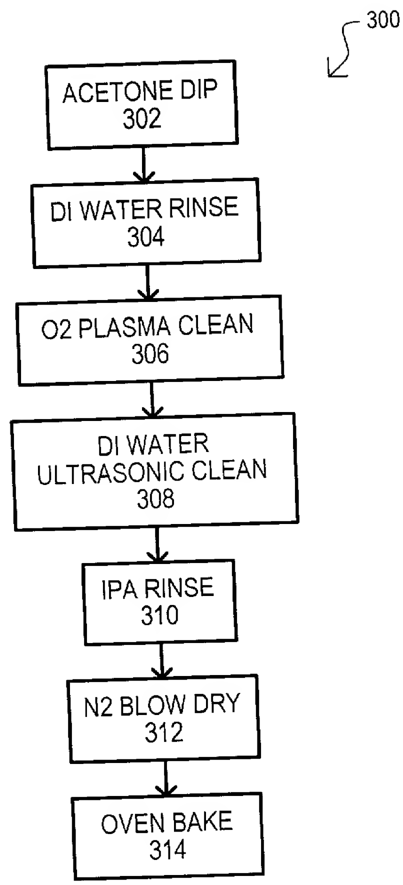
EVAPORATIVE LIQUID RINSE 208
BLOW DRY 210
BAKE 212

FIG. 2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302
DI WATER RINSE
304
O2 PLASMA CLEAN
306
DI WATER
ULTRASONIC CLEAN
308
IPA RINSE
310
N2 BLOW DRY
312
OVEN BAKE
314

FIG. 3

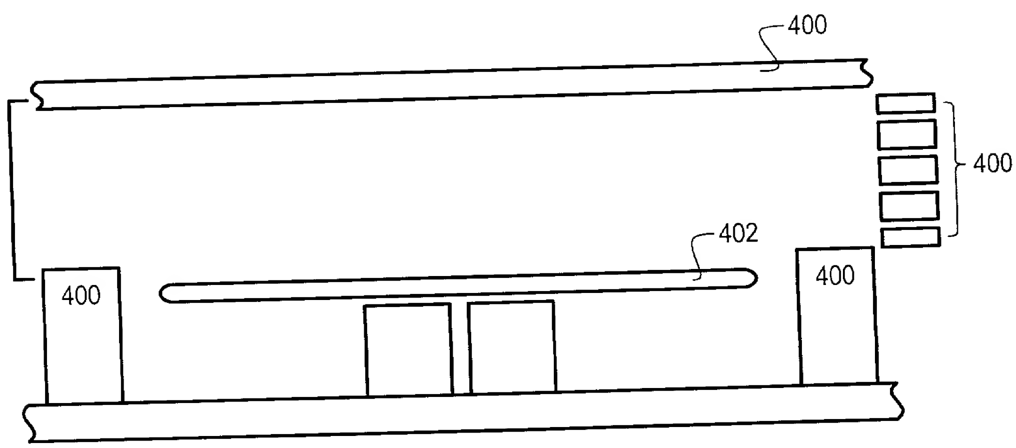
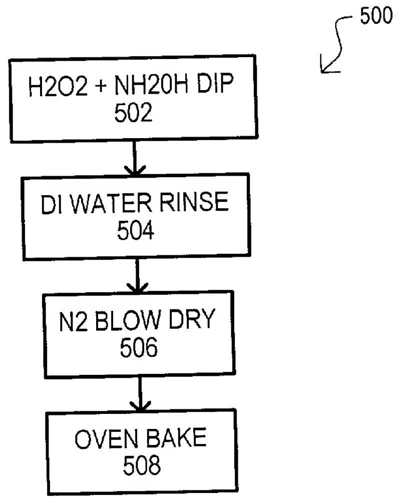

400
400
402
400
400

FIG. 4

FIG. 5


500
H2O2 + NH20H DIP
502
DI WATER RINSE
504
N2 BLOW DRY
506
OVEN BAKE
508

PATENT APPLICATION

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION — **ATTORNEY DOCKET NO. [illegible]**

As a below named inventor, I hereby declare that:

My residence/post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

<u>Method for Cleaning Plasma Etch Chamber Structures</u>

the specification of which is attached hereto unless the following box is checked:

( ) was filed on ______________ as US Application Serial No. or PCT International Application Number ______________ and was amended on ______________ (if applicable).

I hereby state that I have reviewed and understood the contents of the above-identified specification, including the claims, as amended by any amendment(s) referred to above. I acknowledge the duty to disclose all information which is material to patentability as defined in 37 CFR 1.56.

Foreign Application(s) and/or Claim of Foreign Priority

I hereby claim foreign priority benefits under Title 35, United States Code Section 119 of any foreign application(s) for patent or inventor(s) certificate listed below and have also identified below any foreign application for patent or inventor(s) certificate having a filing date before that of the application on which priority is claimed:

COUNTRY	APPLICATION NUMBER	DATE FILED	PRIORITY CLAIMED UNDER 35 U.S.C. 119
			YES:____ NO:
			YES:____ NO:

Provisional Application

I hereby claim the benefit under Title 35, United States Code Section 119(e) of any United States provisional application(s) listed below:

APPLICATION SERIAL NUMBER	FILING DATE

U.S. Priority Claim

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, Section 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

APPLICATION SERIAL NUMBER	FILING DATE	STATUS(patented/pending/abandoned)

POWER OF ATTORNEY:

As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) listed below to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

Bradley Sako, Reg. No. 37923

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Bradley T. Sako 3054 Loch Lomond Way Livermore, CA 94550	Bradley Sako 1-408-839-1082

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Post Office Address: <u>Same</u>

Walter G Branco
Inventor's Signature

7/13/00
Date

PATENT APPLICATION

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION **ATTORNEY DOCKET NO. [illegible]**

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Citizenship: U.S.A.

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Post Office Address: Same

Inventor's Signature

7/13/00

Date